CONTINUOUS COMMISSIONING OF SALT LAKE COMMUNITY COLLEGE SOUTH CITY CAMPUS

Song Deng, P.E. and Dan Turner, P.E., Ph.D., *Energy Systems Laboratory*, *Texas A&M University System, College Station, Texas*

Jim Hood, P.E., *Utah Department of Natural Resources, Salt Lake City, Utah*

Summary The State of Utah's Department of Natural Resources funded two projects in Salt Lake City to demonstrate the feasibility of the Continuous Commissioning® (CC®)[1] process. The two sites selected were a modern state building, the Matheson Courthouse [1], and a very old building, the South City campus of Salt Lake Community College. This paper describes the measures and savings results from the CC® process at the Community College. The energy savings amounted to 15% of the annual utility bill. While most of the savings were attributed to CC, part was attributed to the on-site facility operators who implemented measures over and above those recommended by the CC engineers. It was an exciting team effort and a good example of the savings that can be achieved by CC engineers working closely with a good facility operations staff.

Keywords: continuous commissioning, building energy efficiency, retrocommissioning, ongoing commissioning

INTRODUCTION

The South City Campus of Salt Lake Community College in Salt Lake City, Utah, was an old high school building originally occupied in the 1930's. It was shut down as a high school, was vacant for years, and was renovated and opened as a community college in the 1980's. The complex consists of 350,000 ft^2 and contains classrooms, offices, labs, a cafeteria, two gymnasiums, an auditorium, and a swimming pool. A photograph is shown in Figure 1. All the areas are centrally heated, and all areas except the swimming pool are centrally cooled. The Community College is typical of most educational institutions of its type in that it caters to many part-time students, and it has night classes until as late as 10 p.m., serving adults who work full-time during the day.

Figure 1. Photograph of South City Campus, Salt Lake City, Utah

The South City campus, prior to commissioning, was already well run. The building automation system is a modern DDC system, but the DDC extends only to the air handler unit (AHU) level. The boxes are all pneumatic. The energy cost index

[1] Continuous Commissioning and CC are registered trademarks of the Texas Engineering Experiment Station (TEES), the Texas A&M University System, College Station, Texas

(ECI) was very cheap, averaging about $0.97 per square foot per year. The low cost index is attributable to two factors—low cost of energy and good energy management practices.

HVAC Equipment

The installed equipment at the South City campus consists of two (2) 300-ton and one (1) 130-ton chillers. There are three (3) low-pressure steam boilers, two (2) rated at 500 Boiler horsepower and one (1) rated at 150 Boiler horsepower. There are thirty (30) major air handling units. Most are single-duct, variable air volume (VAV), with terminal reheat, with some constant volume and some multizone units. Those units without terminal reheat generally have space perimeter hot water heating around exterior zones. The building automation system is a modern DDC system with controls to the AHU level.

CC Team

Continuous Commissioning is a process developed by the Energy Systems Lab at Texas A&M University to improve occupant comfort and reduce energy consumption. Comfort is not sacrificed, and improved worker productivity should be a result because the building occupants are provided a better work environment. CC is a team effort and will be successful only if all parties are involved in the initiative. At the South City campus, the team consisted of a representative from the Utah Department of Natural Resources (project sponsor), the campus lead HVAC technician, the campus facility manager, and two CC engineers from the Energy Systems Laboratory.

CC Process

Continuous Commissioning begins with a building walkthrough to assess the operation of the building. In this initial assessment comfort conditions (temperature, humidity, CO_2 levels, HVAC noise) are noted and measured. Discussions are held with operating staff and problem areas, i.e., areas where it is difficult to maintain comfort, are noted. A CC assessment report is then written, documenting the CC measures identified, the comfort problems, savings from implementing the CC process, and the cost of CC implementation. After the client reviewed the report, a decision was made to proceed. Since the Department of Natural Resources was paying the cost of the CC, the Community College was delighted to participate. The CC measures were divided into four (4) principal areas, as follows:

Calibration Issues
Operational Changes
Maintenance Issues
Optimization Measures

Comfort issues were also addressed and improved.

CC MEASURES

Calibration Issues

The starting process in implementing CC is to make sure that all key sensors are working properly and are in calibration. In cooperation with the HVAC technician the calibration of all key temperature sensors was verified and recalibrated, if necessary. Similarly, all duct static pressure sensors were recalibrated. These sensors were generally close to correct, but some adjustments had to be made. The outside air temperature sensor, for example, was correctly placed on the north wall of the building, but during part of the morning hours the sensor was seeing direct sun. This gave too high temperature readings and impacted economizer operation. The facilities staff built a shield over the sensor to prevent direct exposure to the sun. The humidity sensor for the swimming pool area was located initially in the return air grill and was not sensing true humidity levels. The sensor was relocated in the pool area to give a more accurate reading. The initial location caused the exhaust fans to cycle off and on more frequently than necessary. Finally, all outside air and minimum outside air dampers were recalibrated.

Operational Changes

The building was already on a shutdown schedule for nights and weekends, and each AHU was shut down when the area it served was no longer occupied. The team analyzed the trend log data from the BAS and determined that most of the AHUs were reaching set point soon enough that they could be started about an hour later than the initial schedule called for. Also, it was determined from a survey of the room occupancy at night that the AHUs could generally be turned off 30 minutes earlier. Thus about 90 minutes of run time per working day was eliminated from most AHUs.

The practice, prior to the CC implementation, was to run the small boiler in the summer (May to September) to heat the swimming pool, and run the larger boilers for both pool heating and heating hot water for the remaining months. Further, the practice was to alternate the larger boilers twice daily, running the more reliable one at night and then turning on the second boiler when operating personnel arrived on campus the next day. This practice was not energy conserving in that the boilers were being started and run for about 12 hours per day each. The CC engineers noted that even in January weather, the larger boiler was running at about 20%-25% capacity most of the time. Operating a larger boiler at such a small load is not efficient, and cycling it twice a day is not optimum operation. The CC engineers did some load calculations and determined that the smaller boiler could handle the entire building's heating needs and swimming pool heating about 90% of the time during the winter and recommended that it become the lead boiler. One large boiler could be used in a standby mode to provide the extra capacity when it was needed. The CC engineers also recommended that the small boiler be tuned up for maximum efficiency, which was done.

In the course of assessing the hot water needs of the campus, it was noted that too much water was being pumped throughout the system. The temperature difference between the supply and return hot water on a day with outside temperatures of 20ºF was only 2-3ºF. The hot water pump was a 50 hp constant speed pump. We noted a "standby" 15 hp pump not being used and recommended it become the hot water pump. It had the same pressure as the 50 hp pump. A variable frequency drive on the larger pump would be preferable, but no capital budget was available for this project. The 15 hp pump had not been used in seven (7) years, but it was refurbished and placed in service. This change saved 35 hp over the year, i.e., about 2000 operating hours for the hot water pump.

Some of the control loops in the DDC system were unstable or took too long to react. Some of these loops were tuned to provide better control.

The team also changed the operation schedule of the AHU serving the weight room to reflect the schedule of the weight room operation. We recommended that a policy be implemented to use the swimming pool covers on the pools (swimming and diving pools) to reduce heat losses. The pool covers were generally used, but sometimes they would not be covered by the lifeguards.

Maintenance Issues

Although the Community College staff were generally doing a good job in maintaining the facility, the CC process identified some maintenance problems. We discovered several leaking or stuck dampers which were repaired by the operations staff. Exhaust gravity dampers in the pool area were repaired.

Third floor air handling units which were added in a renovation project several years earlier had the booster pumps for the chilled water installed backwards by the contractor. As a result these areas could not get enough chilled water and experienced comfort problems. The CC engineers noted that the pumps could be turned around and would function properly. This was done by the maintenance staff.

One of the few capital expenditures for this project was the addition of insulation to the condensate return tank, condensate lines, and some steam pipe elbows. The steam tunnels were very hot, and this was causing sections of the building to overheat in the spring and fall. The CC engineers recommended that these pipes be insulated, and the facilities manager contracted the work. This allowed the chillers to be left off longer in the spring and to be turned off earlier in the fall.

The small boiler was also tuned up by an external contractor.

CC Optimization Measures Implemented

A cornerstone of the CC process is to install reset schedules for AHUs for hot deck, cold deck and static pressure. Hot deck and cold deck temperature resets were implemented, based on outside air temperature.

The heating hot water was reset also as a function of outside air temperature. The college is a high thermal mass building, and needs little heating, even in the winter. The hot water temperature was reset downwards from its initial values.

The swimming pool exhaust fans ran continuously, prior to the commissioning, for humidity control. This operational scenario brought a lot of cold air into the building and exhausted air from the pool area even when the humidity was low. The CC engineers recommended installing a humidity sensor within the pool area and installing separate starters on each of three exhaust fans. The fans would be staged to come on if humidity levels were high, but would not operate if the pool humidity levels were below 60%.

The economizer control was improved. Prior to CC, the economizer was enabled at 23ºF. This was changed to 35ºF. A mixed air temperature reset schedule was programmed into the multi-zone units.

When outside temperatures were below freezing, the steam coils on each AHU opened fully to prevent freezing. Unfortunately, this resulted in severe overheating of some spaces, caused by natural convection within the AHU. The controls system was reprogrammed to allow modulation of the steam coils to maintain a fixed mixed air temperature. This saved steam as well as prevented overheating of spaces for some of the AHUs.

Comfort Issues Addressed

The swimming pool humidity control was improved, providing closer humidity control as well as reducing energy.

Several classrooms had high noise caused by too much airflow. Duct balancing dampers were used to reduce airflow and reduce classroom noise.

The bookstore manager complained of high temperatures. Working with the HVAC technician, the team found outside air dampers that were not closing and were leaking in large amounts of outdoor air. When these dampers were repaired, colder air was supplied to the bookstore, and temperature control was restored.

The library also experienced high noise levels from the AHU, and the CC engineers recommended resheaving the AHU fan motor to reduce airflow and noise.

CAPITAL RECOMMENDATIONS

1. The CC team recommended the installation of motion sensors in classrooms. Visits to the College, particularly at night, revealed many lights on in unoccupied classrooms.
2. VFD's were recommended on 13 VFD fan motors and the hot water pump.
3. The chillers are not integrated into the DDC system, and it was recommended they be added to give automatic control.

ADDITIONAL MEASURES IMPLEMENTED BY FACILITY MANAGEMENT TEAM

The Facility Management Team became very excited about saving energy and implemented several measures on their own. They managed a complete shutdown of the facility during the Christmas holidays, and they went to a four-day workweek during the summers. Both of these measures saved several thousand dollars a year over and above the CC measures implemented. Figure 2 shows the South City campus (and a sister campus) during the Christmas shutdown, and the four-day workweek electricity profile during the summer.

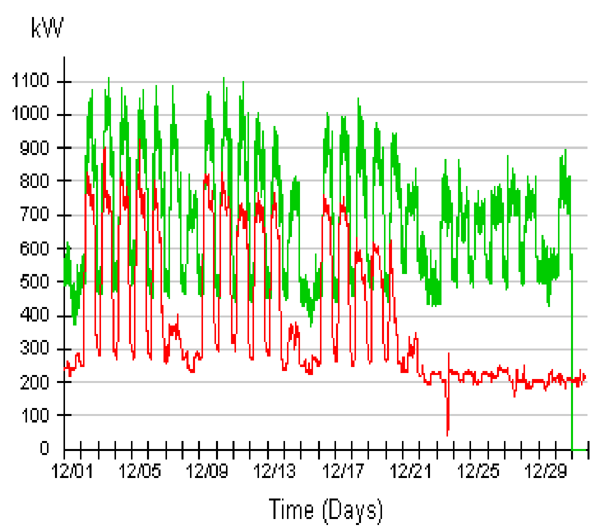

Figure 2. South City Campus and a Sister Campus Over the Christmas Holidays

Note that South City's electric consumption dropped to about 200kW over the holidays, while the other campus varied from 500 kW to 900 kW over the same period.

Figure 3 shows the impact of the four-day workweek on electricity consumption. The weekend consumption was typically around 200 kW.

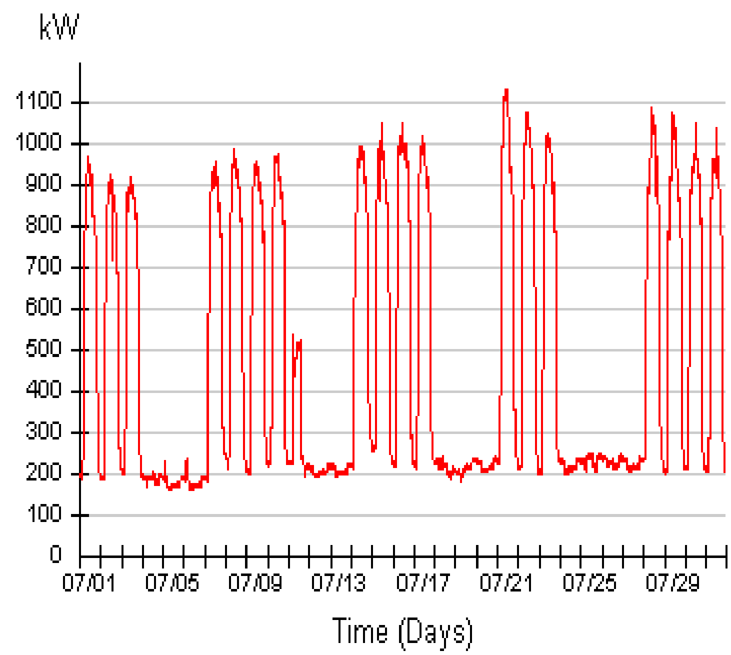

Figure 3. Typical South City Electricity Consumption During 2003 Summer Period

CONTINUOUS COMMISSIONING SAVINGS

Temperature-based regression models based on the 2001-02 utility bills for natural gas and electricity were developed. The commissioning of the College began in January 2003 and continued throughout the year. Visits were made to Salt Lake City by the ESL engineers every two months. Problems identified were fixed on the spot or were given as a "to-do" list for the College staff to complete between the ESL engineers' visits.

Based on the regression model, the calendar year 2003 energy savings were approximately $50,000. The electricity and demand savings were about $11,000, and the natural gas savings were about $39,000. These savings are based on electricity prices of 2.77 cents per kWh and natural gas prices of $5.39/MM Btus. Demand savings were based on $7.96/kW per month. CC measures can take credit for 60 to 70% of the total savings. During 2003 the swimming pool was shut down two months for repair, thus saving pool heating costs. The College also converted to a four-day workweek in the summer and completely shut down for ten days during the Christmas holidays. These measures all saved several thousand dollars, but it is hard to separate the CC measures from the facility-initiated measures using the regression models.

SUMMARY AND CONCLUSIONS

The CC at the Salt Lake Community College campus was a big success. The cost of the CC was less than $50,000, which resulted in a simple payback of less than one year. The energy awareness and technical competency of the facilities staff were increased, and the team interaction generated a lot of enthusiasm for saving even more energy and dollars. In addition to the weekend and holiday shutdowns, in 2004 the swimming pool temperature was lowered one degree and allowed to "float" to a lower temperature, thus saving additional natural gas. The AHU minimum air dampers were kept shut an extra hour in the morning hours because the CO_2 levels were still low enough not to create an IAQ problem. It was exciting to see the local facilities team identify additional energy measures on their own and initiate these actions independently.

In summary, Continuous Commissioning has resulted in savings in excess of 10% of the utility bill, and the combined CC and facilities-initiated measures have reduced an already efficient campus to one of incredible efficiency. The ECI was reduced from a cost of $0.97 per square foot per year to $0.83 per square foot per year.

More information on the CC process can be found in reference 2, the Continuous Commissioning Guidebook written for the United States Federal Energy Management Program.

REFERENCES

1. W. D. Turner, Song Deng, Jim Hood, Mike Butler, R. Kevin Healy. Continuous Commissioning® of the Matheson Courthouse in Salt Lake City, Utah, Presented at ICEBO, Berkeley, CA, September 2003
2. Mingsheng Liu, David E. Claridge, and W. Dan Turner. Continuing Commissioning℠ Guidebook for Federal Energy Managers Federal Energy Management Program, U. S. Department of Energy, October 2002
3. W. D. Turner, Song Deng, Jim Hood, Mike Butler, R. Kevin Healy. Continuous Commissioning® of the Matheson Courthouse in Salt Lake City, Utah. Presented at WEEC, November 2003

ACKNOWLEDGEMENTS

This Continuous Commissioning project was funded by the State of Utah Department of Natural Resources. Jim Hood, P.E., and a member of the project team, is the program manager. The lead HVAC technician and controls operator, Mr. Jerry Jones, was a principal member of the CC team, as was Mr. Bob Lund, South City facilities manager. Both Mr. Jones and Mr. Lund made significant contributions to the CC effort, as did other members of the operations staff at the South City campus.